BB BOSWELL-BÈTA

Attainment Targets VWO Biology

Domain A. Skills

Not Biology specific, therefore not further specified.

Below, example contexts will be given for each subdomain. Hereby the following abbreviations are used:

E	energy	FP	food processing
H	health and health care	S	sport
SU	sustainability	W	world view
N	nutrition	SA	safety

Domain B. Self-regulation

Biology, the science of life, studies life at different levels. At each level there are systems with their own organization, the biological units: the molecules, the cell, the organ, the organism, the population, the ecosystem. Each biological unit is a complex dynamic system, built to deal effectively with its own environment. Each biological unit is a complex system that regulates itself.

Biological units, at whatever organizational level, maintain themselves by absorbing substances or energy from their environment, by repairing damage incurred, by defending themselves against attackers and against harmful substances, and by adapting to or changing their environment. Parts of a biological unit may be specialized for a particular function. Biological units can form a new biological unit with its own organizational structure at a higher level.

The candidate can in a context:

- recognize biological units and describe their characteristics. Those biological units are molecules, cells, organs, organisms, populations, ecosystems;
- explain that there is absorption, processing and release of energy and matter, describing the relationships within and between the different biological units;
- use reasoning in which an associated function is sought from a given form of a biological unit, and vice versa.

Subdomain B1. Protein synthesis

Final objective
Using the concepts of DNA and protein synthesis, the candidate can explain, at least in contexts in the fields of health and food production, how self-regulation takes place at the molecular level.

Example contexts
H: Human geneticists in academic centers conduct experimental DNA research to help patients with Duchenne's disease produce functional dystrophin again.
FP: Biotechnologists at the Genetically Modified Organisms (GMO) Office assess applications for the use of genetically modified crops, with the aim of ensuring safety for people and the environment.
FP: Food technologists at a food production group change DNA and thus protein synthesis with the aim of producing healthier products (functional food).

B 1.1 DNA
Specification
The candidate can in a context:

1. describe the structure of DNA and RNA and explain the differences;
2. name the functions of DNA and mRNA, tRNA and rRNA and describe their relationship with their structure;
3. explain how the base sequence in DNA can be determined.

Sub concepts
nucleic acids, helical structure, base pairing, nucleotide, single-stranded and double-stranded DNA, chromosomes, nucleosomes, histones, nuclear DNA, mitochondrial and chloroplast DNA, RNA, genetic code, plasmid, primer, PCR, sequencing, restriction enzyme, repetitive DNA.

B 1.2 Protein synthesis
Specification
The candidate can in a context:

1. explain how proteins are formed based on the relationship between triplet code and amino acid;
2. describe the process of transcription and translation;
3. explain how the amino acid sequence (primary structure) of a protein determines the structure and function of the protein;
4. explain how proteins determine the construction and functioning of biological units.

Sub concepts
amino acid, primary, secondary, tertiary and quaternary structure, protein, peptide bond, transcription, translation, mRNA, tRNA, rRNA, cytoplasm, ribosome, Golgi system, (rough) endoplasmic reticulum, triplet code, codon, anticodon, coding strand, reading direction, template strand, DNA polymerase, start codon, stop codon, plasmid.

Subdomain B2. Cell metabolism

Final objective
The candidate can use the concepts of homeostasis, transport, anabolism and catabolism to explain, at least in contexts in the fields of health and nutrition, how the metabolism of cells of prokaryotes and eukaryotes proceeds.

Example contexts
H (life environment): Members of a family who may have a hereditary mitochondrial disorder such as MERFF undergo testing at an academic center to determine whether they have the mutated gene with the aim of preparing for possible consequences.
N: Microbiologists at food manufacturers develop microbial tests on food ingredients with the aim of quickly testing ingredients for the presence of dangerous microorganisms.

B 2.1 Homeostasis
Specification
The candidate can in a context:
1. describe characteristics of bacteria;
2. describe a eukaryotic cell as an independently functioning unit, recognize the parts of cells and name their functions;
3. explain that cells maintain themselves by carrying out chemical reactions;
4. explain that the dynamic balance in the cell is maintained in a complex network of cell processes that have diverse functions;
5. explain how homeostasis is achieved in the cell through the feedback principle.

Sub concepts
prokaryote, eukaryote, virus, bacterium, plasmid, cell nucleus, nuclear body, nuclear pore, chromosome, cell wall, cell membrane, vacuole, cytoplasm, cytosol, cytoskeleton, centrioles, mitochondria, (rough) endoplasmic reticulum, Golgi system, ribosome, lysosome, chloroplast, chlorophyll, plastid, cilia, flagella, feedback, receptor protein, effector, cascade, ion pump, dynamic equilibrium.

B 2.2 Transport
Specification
The candidate can in a context:
1. describe forms of active and passive transport and describe the relationship with the properties of the transported substances and the construction and properties of membranes;
2. explain that effects of osmotic action differ in plant and animal cells;
3. explain that due to the presence of a selectively permeable cell membrane, the cell contents are permanently different from the cell environment;
4. recognize the role of the cytoskeleton in transport processes.

Sub concepts
diffusion, osmosis, semi-permeable membrane, selectively permeable, phospholipids, hydrophobic, hydrophilic, receptor protein, ion transport, ion pump, isotonic, hypotonic, hypertonic, plasmolysis, turgor, osmotic pressure, osmotic value, water potential, active transport, passive transport, endo- and exocytosis, cytoplasmic streaming, motor protein, cytoskeleton.

B 2.3 Anabolism and catabolism
Specification
The candidate can in a context:

1. describe that cells absorb and release substances, that the substances are processed in the cells in chemical reactions (construction and breakdown), catalyzed by enzymes;
2. describe that there are different forms of energy: chemical energy (as in ATP), light energy, kinetic energy, heat, and describe that these forms can convert into one another;
3. describe the photosynthesis process in cells with chloroplasts;
4. describe anabolic processes in plants and animals and explain that these processes lead to the production of building materials, fuels, storage substances and enzymes;
5. describe catabolic processes. Distinguish between anaerobic and aerobic cellular respiration;
6. explain anabolic and catabolic processes (including their partial reactions) using reaction equations;
7. describe where and how enzymes catalyze reactions, such as anabolic and catabolic processes, and how temperature and pH affect these;
8. explain how biotechnology uses the metabolism of micro-organisms;
9. explain differences between photosynthesis and chemosynthesis and explain under which conditions both processes can take place.

Sub concepts
autotroph, heterotroph, photosynthesis, C-fixation, chloroplast, light and dark reactions, chemosynthesis, combustion, aerobic, anaerobic, glycolysis, citric acid cycle, oxidative phosphorylation, fermentation, alcohol, lactic acid, methane, ADP and ATP, NAD, NADP, building materials, biological fuels, storage substances, enzymes, phospholipids, intermediate cellulose, carbohydrates (mono, di and polysaccharides, starch, glycogen, cellulose), fat (fatty acids and glycerol), protein, amino acids, DNA, recombinant DNA, pH, denaturation.

Subdomain B3. Metabolism of the organism

Final objective
Using the concepts of organ, photosynthesis, respiration, digestion, excretion and transport, the candidate can, at least in contexts in the fields of health and food production, explain how the metabolism of organisms proceeds and argue how disorders can arise and how these can be addressed.

Example contexts
H (life context): A family in which obesity is common, discuss among themselves the question whether it is a good idea to participate in a trial with a substance that suppresses appetite, with the aim of learning to maintain a healthy weight.
FP: Plant scientists at an academic center research the optimal growing conditions of crops with the aim of providing growers with advice on crop optimization and crop protection.

B 3.1 Organs
Specification
The candidate can in a context:

1. describe how groups of cells perform a common function through their arrangement in a tissue, organ or organ system;
2. describe the characteristics and functions of organ systems for transport, respiration, food processing and excretion in humans;
3. recognize differences and similarities between organs and organ systems of humans and different animal species;
4. explain differences in gas exchange, absorption and transport in prokaryotes, plants and animals;
5. explain how organ systems are related to each other and argue how disturbances in the functioning of an organ affect the cooperation between organs.

Sub concepts
heart, heart valves, artery, vein, capillary, lymphatic system, stomata, xylem and phloem, root hairs, lungs, trachea, bronchi, alveoli, gills, trachea, esophagus, stomach, duodenum, pancreas, liver, gallbladder, small intestine, large intestine, rectum, intestinal villi, circular and longitudinal muscles, kidneys, nephron, sweat glands.

B 3.2 Photosynthesis
Specification
The candidate can in a context:

1. describe that organisms are autotrophic through photosynthesis;
2. name conditions for the process of photosynthesis in plants;
3. describe the importance of photosynthesis as a basis for biosynthesis and cellular respiration in the organism.

Sub concepts
autotroph, heterotroph, (in)organic substances, chloroplasts, net photosynthetic reaction, biosynthesis, limiting factor.

B 3.3 Respiration

Specification

The candidate can in a context:

1. describe the construction, operation and function of gas exchange organs of eukaryotes, in particular humans;
2. describe the relationship between the structure of gas exchange organs and their function, and explain the relationship between the structure and operation;
3. explain how lung ventilation is established and regulated;
4. explain how absorption, transport and release of CO_2 and O_2 take place and what the role of hemoglobin and myoglobin is in this;
5. describe the relationship between the gas exchange of plants and photosynthesis and cellular respiration.

Sub concepts

gas exchange, ventilation movements, lung capacity, vital capacity, dead space, diffusion, Fick's law, CO_2 concentration, O_2 concentration, buffering effect of hemoglobin and HCO_3^-, cellular respiration, biosynthesis, limiting factor.

B 3.4 Digestion

Specification

The candidate can in a context:

1. describe the structure, operation and function of digestive organs of eukaryotes, in particular humans;
2. describe the relationship between the structure of digestive organs and their function and explain the relationship between their structure and function;
3. describe where and how nutrients are digested and absorbed and explain how factors can affect this.

Sub concepts

mechanical and chemical digestion, intestinal peristalsis, nutrients, digestive juices, bile, digestive enzymes for carbohydrates, proteins, fats, vitamins, pH, temperature, digestive products, emulsification, resorption, intestinal bacteria.

B 3.5 Excretion

Specification

The candidate can in a context:

1. describe the construction, operation and function of excretory organs of eukaryotes, in particular humans;
2. describe the relationship between the structure of excretory organs and their function and explain the relationship between their structure and function;
3. explain the role of the liver, kidneys, lungs and skin in excretory processes.

Sub concepts

water balance, ultrafiltration, reabsorption, pre-urine/filtrate, osmotic pressure, ADH, urea, urine, buffering effect of HCO_3^-, bile salts, bile pigments, perspiration.

B 3.6 Transport

Specification

The candidate can in a context:

1. describe the structure, operation and function of the circulatory system with heart and blood vessels of eukaryotes, in particular humans;
2. describe the relationship between the structure of heart and blood vessels and their function and explain the relationship between the structure and function;
3. explain the embryonic circulatory system of humans and identify differences and similarities with the circulatory system after birth;
4. describe the function of the composition of blood, blood plasma, tissue fluid and lymph and explain the formation of tissue fluid and lymph;
5. describes the relationship between the circulatory system and the lymphatic system;
6. describe the transport of water, salts and biosynthesis products in plants and explain the relationship with photosynthesis, cellular respiration and storage of substances.

Sub concepts

open and closed circulation, single and double circulation, pulmonary and systemic circulation, embryonic circulation, blood plasma, tissue fluid, lymph, bone marrow, blood composition, red blood cells, white blood cells, platelets, heart rate, stroke volume, sinus node, AV node, bundle of His, blood pressure, diastole, systole, oxygen transport and carbon dioxide transport, nutrients and waste products, Bohr effect, buffering effect, $HCO3^-$, hemoglobin, myoglobin, blood coagulation, cholesterol, countercurrent principle, filtration pressure, colloid osmotic pressure, evaporation flow, cohesion, adhesion, root pressure, edema.

Subdomain B4. Self-regulation of the organism

Final objective

Using the concepts of homeostasis, hormonal regulation and neural regulation, the candidate can, at least in contexts in the field of sports and nutrition, explain how self-regulation works in eukaryotes and argue how disorders can arise and how these can be prevented.

Example contexts

S: The exercise physiologist in a national training center examines blood values in order to optimize sports performance together with the athlete.
N: Doctors and medical biologists and psychobiologists conduct behavioral research in a trial to determine the possible effect of foods on neural and hormonal regulation in ADHD.

B 4.1 Homeostasis

Specification

The candidate can in a context:

1. describe the importance of the lungs, liver, kidneys, skin, nervous and endocrine systems for homeostasis in humans;
2. describe the relationship between the structure of the liver, lungs, skin and kidneys and homeostasis
3. deduce a control loop from a description of the regulation of body processes and explain the principles of a control loop;
4. describe the coherence of the regulation of body processes;
5. argue how disruption of the dynamic equilibrium can arise and how this can be regulated.

Sub concepts

nervous system, endocrine system, receptors, internal and external environment, control loop, positive and negative feedback, dynamic balance, receptors in cell membranes and cytoplasm, osmotic pressure, pH, temperature, chemical composition, O_2 concentration, CO_2 concentration, buffering effect of hemoglobin and HCO_3^-, glucose concentration, water balance, chemical and pressure receptors in the aorta, pCO_2, pO_2.

B 4.2 Hormonal regulation

Specification

The candidate can in a context:

1. predict the functioning of a control loop in the endocrine system;
2. describe the functioning of endocrine glands and the specific action of their hormones and deduce how the target organs respond to them;
3. describe the relationship between hormonal regulation and the maintenance of homeostasis;
4. explain the relationship between the endocrine system and the sensory, muscular, and nervous systems.

Sub concepts

endocrine glands, pituitary gland, hypothalamus, thyroid, kidneys, adrenal glands, ovaries, testes, islets of Langerhans, exocrine, endocrine, target organs, receptor, hormone concentration, insulin, glucagon, adrenaline, thyroid hormone, digestive hormones, EPO.

B 4.3 Neural regulation

Specification

The candidate can in a context:

1. describe the structure and functioning of the nervous system and signal processing;
2. explain the operation of a control loop in the nervous system;
3. describe the relationship between the functioning of the nervous system and the functioning of an organism;

4. explain the relationship between the nervous system and the sensory, muscular and hormonal systems.

Sub concepts
central nervous system, peripheral nervous system, cerebrum and cerebellum, centers in the cerebral cortex, white matter, gray matter, brainstem, spinal cord, autonomic (vegetative) nervous system, animal nervous system, (para)sympathetic, sensory, relay, and motor neurons, Schwann cells, myelin sheath, synapse, Na/K pump, impulse conduction, saltatory conduction, reflex arc, neurotransmitter, resting potential, action potential, stimulus threshold, refractory period, excitatory, inhibitory, stimuli, temperature, light, touch, and pain receptors.

Subdomain B5. Immunity of the organism

Final objective
Using the concept of immunity, the candidate can, at least in healthcare and food production contexts, identify how organisms defend themselves against other organisms, viruses and allergens, and argue which problems may arise and how these can be addressed.

Example contexts
H: Virologists from the RIVM annually conduct research into the expected types of flu viruses in order to provide advice on the composition of the flu vaccine with the aim of preventing flu in people with reduced resistance.
FP: Microbiologists from the Food and Consumer Product Safety Authority are studying whether vegetables in the Netherlands are contaminated with the intestinal bacteria EHEC, a variant of *E. coli* bacteria, to prevent an epidemic of food poisoning.
H (life context): Students discuss the use of antibiotics in livestock farming on the basis of reports from the newspaper in order to arrive at a well-considered judgment about that use.

B 5.1 Immunity
Specification
The candidate can in a context:

1. describe the structure, operation and function of organs and cells involved in human defense and explain their mutual relationship;
2. describe the functioning of the specific and non-specific defenses and explain the response to endogenous and foreign substances and cells;
3. recognize the defense mechanisms of plants.

Sub concepts
skin and mucous membranes, blood, lymph, spleen, lymph nodes, humoral and cellular response, macrophages, T and B cells, mediators, antigens and antibodies, endogenous, foreign, MHC-I and MHC-II, natural and artificial immunity, active and passive immunity, vaccination, transplantation, blood transfusion, AB0 system, Rhesus factor, donor, acceptor, mechanical and chemical defense of plants, resistance.

Subdomain B8. Regulation of ecosystems

Final objective
The candidate can explain, at least in contexts in the field of sustainability, how ecosystems regulate themselves using the concepts of energy flow, cycle, dynamics and balance; the candidate can argue which effects can occur if self-regulation of ecosystems and the Earth system is disrupted, and can argue with which measures humans can affect self-regulation of ecosystems and the Earth system.

Example contexts
D: Environmental biologists and ecologists in a Sustainability Committee inform the minister about environmental aspects of importing soy from Brazil as pig feed with the aim of promoting sustainability.

B 8.1 Energy flow
Specification
The candidate can in a context:

1. describe energy flows in an ecosystem, explain which factors affect them and explain the causes and effects of disruption;
2. describe models of energy flow and explain which processes and organisms play a role in them;
3. argue with which measures humans can affect energy flows.

Sub concepts
producer, consumer, decomposer, trophic levels, photo- and chemo-autotroph, heterotroph, (in)organic substances, GPP, NPP, productivity, fossil fuel, biofuel, biomass.

B 8.2 Cycle
Specification
The candidate can in a context:

1. explain the role of producers, consumers and decomposers in carbon and nitrogen cycles and quantify the relationships;
2. show cycles of elements in an ecosystem, explain which factors influence the various steps therein and explain the causes and consequences of disruption;
3. argue with which measures humans can affect nutrient cycles and thus the Earth system.

Sub concepts
photosynthesis, cellular respiration, (de)nitrification, ammonification, nitrogen fixation, (in)organic matter, leaching, eutrophication, biomass, greenhouse effect, greenhouse gases.

B 8.3 Dynamics and equilibrium
Specification
The candidate can in a context:

1. describe what is meant by an ecosystem and which components are part of it;
2. explain the role that competition within and between populations plays in the dynamics (maintenance and development) of an ecosystem;
3. explain the role biotic and abiotic factors play in the dynamics within an ecosystem;
4. argue with which measures humans can affect the self-regulation of ecosystems.

Sub concepts
niche, microclimate, biodiversity, migration, invasive species.

Domain C. Self-organization

Biological units can be regarded as systems with an organization. Biological units differ from non-living systems in that they themselves are the only product of their organization, that is, there is no separation between producer and product. They organize themselves.

Through self-organization, new structures, 'biological units of a higher order', can arise. At the higher organizational level, new properties can be seen that the biological unit of the lower organizational level does not have, the so-called emergent properties.

An example is the biological clock in humans: some clock cells are active during the day, other clock cells at night, and others peak in the morning. The sum of these has a property that the individual cells do not have: the biological clock can register the length of the day and the time of year. So, the whole is more than the sum of its parts.

The candidate can in a context:

- explain that biological units from the cellular level up to and including the level of a population have a self-organizing capacity;
- argue that biological units have new, emergent properties compared to the biological units one level lower.

Subdomain C1. Self-organization of cells
Final objective
Using the concepts of gene expression and cell differentiation, the candidate can, at least in contexts in the field of health and food production, identify how cells develop and argue how developmental disorders can arise and be addressed.

Example contexts
H: Biologists at a transplant center grow stem cells and allow them to differentiate into specialized cells with the aim of replacing damaged tissue in the human body and thereby healing people.

FP: Biologists and plant scientists in public-private partnerships realize plant breeding aimed at changing the proportions of constituents (amylopectin potato) with the aim of making the processing process more energy efficient and simpler.

C 1.1 Gene expression

Specification

The candidate can in a context:

1. show that DNA in eukaryotes is largely non-coding and that genes consist largely of introns;
2. describe the process from gene expression to protein synthesis;
3. describe that genes are expressed depending on the circumstances;
4. explain that different proteins are made in different types of cells;
5. explain how gene expression and the functioning of an organism are related.

Sub concepts

chromosome, gene, DNA, RNA, protein, phenotype, genetic code, start codon, stop codon, transcription factor, activator, RNA polymerase, splicing, introns, exons, nucleosomes, non-coding DNA, cDNA, knockout gene.

C 1.2 Cell differentiation

Specification

The candidate can in a context:

1. describe that virtually all cells of a multicellular organism have the same genome;
2. describe how differentiation creates cells with a different shape and function;
3. describe that cell differentiation is achieved by switching genes on and/or off;
4. describe properties of stem cells and explain for what purposes stem cells can be used;
5. explain that a cell is capable of apoptosis and that this can play a role during the development of a multicellular organism.

Sub concepts

genome, stem cells, cell type, intermediate cell substance, apoptosis, lysosome, pluripotent, omnipotent, cancer.

Subdomain C3. Self-organization of ecosystems

Final objective

Using the concepts of dynamics and equilibrium, the candidate can, at least in contexts in the field of sustainability and worldview, identify how ecosystems can develop and argue with which measures humans affect the self-organization of ecosystems and the Earth system.

Example contexts

SU: Biologists, landscape architects and engineers at Rijkswaterstaat conduct research into the development of nature and the possibilities of building with nature with the aim of protecting the coast.

SU: The aquatic ecologist from a research institute investigates the food relations in the Oostvaardersplassen with the aim of developing a sustainable management plan.
W: Biologists employed by the Spatial Planning department of a municipality conduct research into citizens' perception of nature with the aim of taking this into account in zoning plans.

C 3.1 Dynamics and equilibrium
Specification
The candidate can in a context:

1. describe the development of an ecosystem;
2. describe successive changes in an ecosystem and explain how transitions are achieved;
3. identify differences between ecosystems based on differences in populations (biotic) and abiotic factors;
4. describe the dynamics in an ecosystem;
5. recognize that an ecosystem can be in different equilibrium situations;
6. argue with which measures humans influence the self-organization of ecosystems and the Earth system.

Sub concepts
succession, pioneer species, climax ecosystem, gradient ecosystem, indicator species, biodiversity, gene pool, competition, carrying capacity, tolerance limits, invasive species, tipping point, growth curves.

Domain D. Interaction

Biological units are affected by their environment, which can be either biotic or abiotic in nature. The biological units can respond to this influence by adapting, moving or exhibiting other reactions. Conversely, biological units also affect their biotic and abiotic environments.

Interaction refers to the open nature of biological systems.

The candidate can in a context:

- argue that a biological unit, at any organizational level, is in constant interaction with the environment, including other biological units;
- use reasoning that elaborates on the consequences of internal or external changes in a biological unit for that biological unit and for the biological units at a higher and lower organizational level;
- describe the complexity of relationships in and between biological units and of biological units with their abiotic environment.

Subdomain D1. Molecular interaction

Final objective

Using the concepts of gene regulation and interaction with (a)biotic factors, the candidate can explain, at least in health and food production contexts, how molecular regulation takes place.

Example contexts

H: Biologists, chemists and doctors in an academic collaboration investigate gene expression in order to use chemotherapy in the most targeted manner possible in cancer patients with the aim of curing them.

FP: Plant breeders at a breeding company use GMO to change molecular processes to create drought resistance or salt tolerance in plants, with the aim of also making cultivation possible on the edges of deserts and in brackish deltas and thus tackling the hunger problem.

D 1.1 Gene regulation and interaction with (a)biotic factors

Specification

The candidate can in a context:

1. list mechanisms for gene regulation and explain their importance;
2. explain that cells use proteins for their function;
3. explain that (a)biotic factors affect the variation in proteins;
4. explain that gene expression is a dynamic process that is regulated by various factors including epigenetic ones;
5. explain that mutagenic factors disrupt gene regulation.

Sub concepts

genome, structural genes, regulator genes, recombinant DNA, proto-oncogenes, enzymes, virus, RNAi, promoter, operator, repressor, suppressor, epigenetic, cisgenic, transgenic.

Subdomain D2. Cellular interaction

Final objective

Using the concepts of cell communication and interaction with (a)biotic factors, the candidate can identify the way in which cellular interaction takes place, at least in health contexts.

Example contexts

H: Biologists conduct research in a research institute on *C. elegans* into cell communication and the effects of (a)biotic factors on it, in order to gain knowledge about cell communication from research on this model organism in the context of possibly curing people with an abnormality in cell communication.

D 2.1 Cell communication and interaction with (a)biotic factors

Specification

The candidate can in a context:

1. describe how cells receive and process signals, how cells respond to signals, and relate these processes to each other;
2. recognize how cells communicate with each other over short and long distances via nerve cells and hormones;
3. distinguish that there are responses in the cell plasma and that there are responses that promote gene expression;
4. deduce what effects cell communication has on other organizational levels.

Sub concepts

signaling substances, second messenger, synapse, cell junctions, receptor, response, signaling cascade, Na/K pump.

Subdomain D5. Interaction in ecosystems

Final objective

Using the concepts of food relationship and interaction with (a)biotic factors, the candidate can, at least in contexts in the fields of sustainability and food production, identify which relationships exist between populations and ecosystems and argue how issues related to these can be addressed.

Example contexts

FP: Agronomists and greenhouse construction technologists investigate the possibilities for cycle management in the greenhouse for a tomato grower with the aim of reducing energy use and increasing product diversity, making crops competitive and reducing dependence on a product.
SU: Students determine their own ecological footprint and discuss among themselves how each individual can actually reduce their ecological footprint.

D 5.1 Food relationship

Specification

The candidate can in a context:

1. describe feeding relationships between organisms;
2. identify relationships in a food chain;
3. recognize food chains in a food web.

Sub concepts

trophic levels, predation, feeding, signaling substances, symbiosis, parasitism, mutualism, commensalism.

D 5.2 Interaction with (a)biotic factors
Specification
The candidate can in a context:

1. describe changes in abiotic and biotic factors and their mutual interaction in an ecosystem;
2. describe the role abiotic and biotic factors play in the maintenance and development of an ecosystem;
3. explain the accumulation of toxic substances in a food chain;
4. describe the role of competition within and between populations in an ecosystem;
5. describe what is meant by sustainable development, in particular sustainable energy and food production;
6. argue how issues relating to sustainable development can be approached.

Sub concepts
microclimate, niche, indicator species, limiting factor, tolerance, optimum, persistent, biodegradable, habitat.

Domain E. Reproduction

Biological units, such as cell organelles, cells and organisms, replicate.

The candidate can in a context:

- describe relationships between replication that takes place at different organizational levels.

Subdomain E3. Reproduction of the organism
Final objective
Using the concepts of reproduction and hereditary traits, the candidate can explain, at least in contexts in the fields of energy, health, and food production, how traits are transferred and identify how the reproduction of eukaryotes and prokaryotes takes place.

Example contexts
E: Biologists and biophysicists in an algal testing facility conduct cell biological and physical research into effects on the reproduction of algae for the purpose of cultivation optimization in the context of energy generation and oil production.
H: Students in a class create their own information brochure about sexuality and STDs, aimed at reducing STDs and their early detection.
FP: Biologists working at Greenpeace create information materials to alert the public to possible disadvantages of Genetically Modified Organisms for the purpose of educating the public.

E 3.1 Reproduction

Specification

The candidate can in a context:

1. describe sexual and asexual reproduction and thus explain the genetic variation in prokaryotes and eukaryotes;
2. describe the structure, formation, development and function of gametes and the zygote;
3. describe the structure and functioning of the human reproductive organs and explain the role of hormones in this;
4. explain positions on intervening in the reproductive process of organisms with ethical and biological arguments.

Sub concepts

life cycle, sexual and asexual reproduction, reproductive organs of eukaryotes, gametes, spore, mitosis, meiosis, haploid, diploid, polyploid, fertilization, egg cell, sperm cell, follicle, yellow body, zygote, cleavage division, polar body, embryo, placenta, sex hormones, FSH, LH, estrogen, progesterone, testosterone, HCG, menstrual cycle, contraception, artificial insemination, in vitro fertilization, embryonic development, cloning.

E 3.2 Hereditary characteristic

Specification

The candidate can in a context:

1. explain that a phenotype is created by the combination of genotype and the effect of environmental factors, and recognize differences with epigenetic inheritance;
2. identify the differences between autosomes and sex chromosomes and explain that in humans the sex chromosomes determine gender;
3. determine the frequency of genotypes and phenotypes of offspring from pedigrees or crossing schemes in monohybrid and dihybrid crosses, both for independent and linked inheritance, for autosomal and X-chromosomal genes, multiple alleles and lethal factors;
4. explain that mitochondrial inheritance and epigenetics can lead to a different inheritance pattern than according to Mendel's laws;
5. explain positions on intervening in the heredity of prokaryotic and eukaryotic organisms with ethical and biological arguments.

Sub concepts

genome, autosomes, X and Y chromosomes, genotype, phenotype, allele, gene, monohybrid and dihybrid crossings, (incomplete) dominance, recessive, intermediate, multiple alleles, lethal factor, linked genes, pedigree, mitochondrial DNA, epigenetics, methylation.

Domain F. Evolution

Biological units interact with each other at all organizational levels, influenced by biotic and abiotic factors. There is competition for space, light, food and so on. The chance of surviving and producing offspring is greatest for biological units that best suit the circumstances, that can adapt the circumstances or that can seek out the best conditions. Evolution shows how chance, mutation, recombination, variation, adaptation and selection pressure have led to the biodiversity we have today.

The candidate can in a context:

- explain how biodiversity of life originated;
- explain that the existence of the universal genetic code is understood as a scientific argument for a common origin and relationship of all life;
- use reasoning that explains the role of adaptations in biological units;
- use reasoning in which an associated function is sought from a given form of a biological unit and explain that a certain functionality may have arisen along different paths in evolution;
- explain how the theory of evolution came about and argue about the interaction of the theory of evolution with science, society and philosophy.

Subdomain F1. Selection

Final objective

The candidate can use the concepts of DNA, mutation, genetic variation, recombination and population to explain how variation in populations is created, at least in contexts in the fields of health and food production.

Example contexts

H: Doctors in Japan are investigating mutations caused by different doses of radiation using sequencing with the aim of providing optimal protection advice when working with radiation.

FP: The plant breeder and taxonomists of a Genetic Resources Institute develop new varieties of food crops using knowledge of taxonomy and breeding techniques and search for genetic sources that make the food crops pest-resistant or taste better.

F 1.1 DNA

Specification

The candidate can in a context:

1. state that DNA functions as a universal carrier of genetic information;
2. explain that the same genetic information can occur in different organisms;
3. explain how data obtained by DNA analysis can be used to determine the degree of relatedness of species.

Sub concepts

DNA, genetic code, genotype, phenotype.

F 1.2 Mutation
Specification
The candidate can in a context:

1. describe what types of mutation there are;
2. explain what can cause mutations;
3. explain that mutations can influence the phenotype;
4. explain that a mutation occurs independently of its possible effect on the chances of survival or reproduction of the cell or organism.

Sub concepts
chromosome, mutagen, mutagenic radiation, point mutation, deletion, insertion, genome mutation, gene, allele, genetic modification, DNA repair system, frameshift mutation.

F 1.3 Mutation
Specification
The candidate can in a context:

1. explain how, during sexual reproduction, reproductive cells with a unique combination of genes are created by recombination of chromosomes and parts thereof.

Sub concepts
meiosis, homologous chromosomes, autosomes, sex chromosomes, karyotype, haplotype, genome, linked genes, crossing over.

F 1.4 Genetic variation
Specification
The candidate can in a context:

1. explain how genetic variation in a population is increased by mutation and recombination;
2. explain how gene combinations are obtained through genetic modification.

Sub concepts
mutation, recombination, phenotype, genotype, gene pool, genetic modification.

Subdomain F2. Species
Final objective
The candidate can use the concepts of population, variation, selection and speciation to explain, at least in health and worldview contexts, how new species can arise.

Example contexts
H: The bacteriologist at the hospital continuously conducts research into changing populations of resistant bacteria in the context of infection prevention.
W: Evolutionary biologists at the National Center for Biodiversity investigate genetic relationships using trait analyzes of plants supplemented with DNA/RNA analyses and

use the data to construct phylogenetic family trees with the aim of better understanding the evolution of plants.

F 2.1 Population

Specification

The candidate can in a context:

1. describe what is meant by a population;
2. explain how frequencies of genotypes and phenotypes in populations change over time and space;
3. explain that populations have emergent properties.

Sub concepts

population, genotype, phenotype, emergent property

F 2.2 Variation

Specification

The candidate can in a context:

1. describe what is meant by genetic variation in a population;
2. explain how allele frequencies/gene frequencies can change in a population due to random mutations, genetic drift and gene flow;
3. Quantify relationships between allele frequencies/gene frequencies and frequencies of genotypes of successive generations using the Hardy-Weinberg rule.

Sub concepts

adaptation, fitness, natural selection, genetic drift, gene flow, allele frequency, Hardy-Weinberg.

F 2.3 Selection

Specification

The candidate can in a context:

1. explain that adaptation of populations is brought about by selection of organisms;
2. explain that selection pressure brings together adaptations that increase the reproductive success of the species;
3. describe similarities and differences between natural and artificial selection.

Sub concepts

adaptation, fitness, selection pressure, species, natural selection, sexual selection, island theory, founder effect, bottleneck effect, breeding, inbreeding

F 2.4 Species

Specification

The candidate can in a context:

1. describe that species are groups of individuals that are reproductively isolated from each other;
2. explain that populations diverge through genetic drift, mutation and selection;
3. explain that species arise through reproductive isolation;
4. explain how the relationship and descent of species can be represented in the form of a cladogram.

Sub concepts

species, genus, cladogram, clade, taxon, homology, analogy, genetic drift, coevolution, sympatric and allopatric speciation.

Abstracted and translated from CvTE Syllabus VWO Biologie 2024 (examenblad.nl)

Boswell-Bèta, May 2024